R & D

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U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Carbon Sequestration Science

3/2007

Geological Sequestration

The impact of greenhouse gases (GHG) in the earth's atmosphere on global climate trends is potentially significant, and NETL is leading scientific research efforts to reduce or eliminate emissions of these gases. Carbon dioxide (CO_2) is the focus of this work because, from a volume standpoint, it is the most significant GHG in combustion products from fossil-fuel-fired power plants. Geological sequestration of CO_2, whether by enhanced oil recovery (EOR), coal-bed methane (CBM) recovery, or deep saline aquifer injection, is a promising method of CO_2 storage. Tremendous experience exists for enhanced oil recovery, and CBM recovery has been demonstrated in several existing fields, but saline aquifer injection studies are in their preliminary stages. The long-term fate of CO_2 injected into these ancient aqueous systems is still uncertain. Migration of CO_2 beyond the boundaries of a reservoir engineered for sequestration will be unacceptable. Strategies to prevent and remediate CO_2 migration must be identified prior to full-scale implementation of any geological sequestration option. Mineral carbonation is one of the processes identified as contributing to effective geological sequestration. Once CO_2 is injected deep underground in saline aquifers, in situ mineral carbonation will occur at natural geological rates potentially enhancing the reservoir seals over time and preventing migration of the CO_2. Promoting the effects of mineral carbonation to enhance natural seals or emplace new seals could significantly improve the odds that deep saline aquifers will be used for long-term CO_2 sequestration.

Studies at NETL are underway to evaluate methodologies for improving reservoir seal integrity, such as:

1. Co-injection of a pre-dissolved mineral slurry with the CO_2 at the main injection well;
2. Injection of a pre-dissolved mineral slurry at strategic sites within the target aquifer horizon;
3. Plugging of existing wells with a reactive mineral-modified oil well cement; and
4. Plugging of the main CO_2 injection wells with a reactive mineral-modified oil well cement, designed to cure within the supercritical CO_2 environment.

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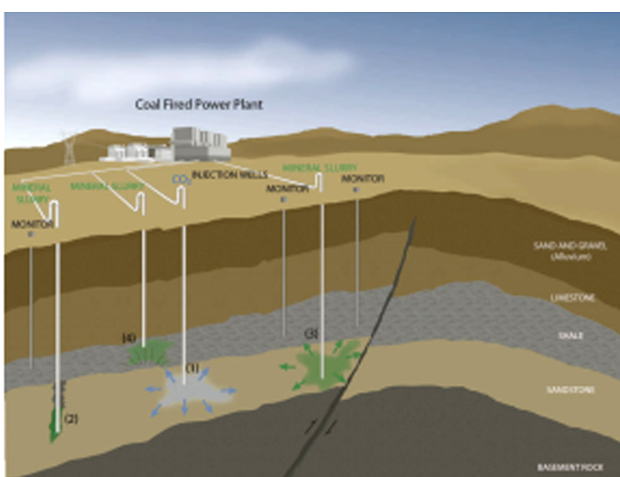
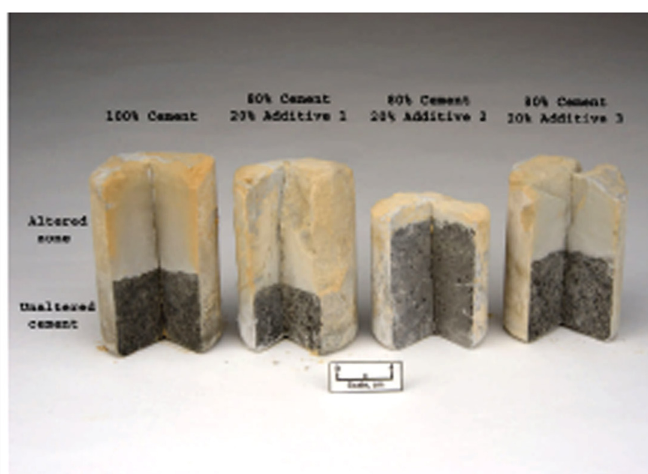
The reactive minerals used to formulate the slurry and oil well cements are intended to supply the necessary cations (Ca_2+, Mg_2+, and Fe_2+) to form solid carbonate minerals. The key to co-injection of a mineral slurry is to maximize seal enhancement, reducing localized porosity in the reservoir, without inhibiting CO_2 injection capacity. Successful oil well cement modifications will improve the physical and chemical properties of the cement plugs that prevent loss of CO_2 at the injection site.

NETL's experimental program is addressing the impact of CO_2 and mineral slurry injection on reservoir and aquitard rock, and the characteristics and behavior of modified oil-well cements. NETL's scientists study the physical and geochemical characteristics of rock-core samples and modified cements before and after exposure to conditions found in a CO_2 injection environment. The results will be improved methods of sealing CO_2 sequestration reservoirs and improved data for models of CO_2 plume migration within these engineered reservoirs.

Autoclaves in series are used for immersing rock and cement specimens in supercritical CO_2





Supercritical CO_2 curing simulates the conditions cement will be exposed to when plugging a CO_2 injection well. Standard cement (left) and cement modified with different mineral additives show different degrees of carbonation and different physical properties.